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ABSTRACT

This study was an initial effort at Brenau College (Georgia) to analyze the relative effectiveness of a self-paced math lab approach to developmental pre-college algebra. Students enrolled in 1988-89 were taught under the lecture method; this applied to students needing both developmental arithmetic and developmental algebra. During the subsequent academic year (1989-90) subjects were divided into two groups: (1) students needing both developmental arithmetic and developmental algebra were placed in the math lab format; and (2) students needing only developmental algebra were placed in the lecture format. Three assessments were made. In the third of these, the differences in student performance prepared under the lab format in 1989-90 were compared to the lecture delivery format of 1988-89; the laboratory format produced the significantly higher mean score. This study includes an introduction, background and significance, procedures, results, and discussion, implications, and recommendations. (KR)

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ED328452

A STUDY OF THE SELF-PACED MATH LAB APPROACH TO DEVELOPMENTAL ALGEBRA COMPARED TO THE TRADITIONAL LECTURE METHOD AT BRENAU

Learning Theory and Applications

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ABSTRACT

This study was an initial effort to analyze the relative effectiveness to date of the self-paced math lab approach to developmental pre-college algebra at Brenau College. The subjects for the study were the 1989-1990 DS 102/104 students needing both developmental arithmetic and developmental algebra and placed into the math lab format in fall 1989;the DS 104 students needing only developmental algebra and placed into the lecture format in fall 1989; and the 1988-1989 academic year DS 102/104 placements under the lecture format.

Three t/z tests were performed to discover any significant difference in performance between students prepared under the lab format as compared to the lecture delivery format. The mean DS 104 (developmental algebra) final exam grades of students completing both developmental arithmetic and developmental algebra in one quarter of the lab format were compared to the mean score of students placed into and completing developmental algebra in the traditional lecture format, fall 1989; the mean algebra course grades of students coming into algebra from one quarter of lab format were compared to those coming from the lecture format, fall 1989; and finally the mean DS 104 final exam grades after two quarters of lecture format developmental math, 1988-1989, were compared to the mean of

grades obtained after two quarters of the lab format by students enrolled in 1989-1990.

The results of the t/z tests revealed no significant difference between the mean DS 104 final exam grades when fall 1989 lab and lecture completers were compared. Likewise, no significant difference was found when winter 1990 algebra grade means of previous lab and lecture students were compared. The third test comparing the DS 104 final exam grade means of 1989-1990 lecture-prepared students with the 1989-1990 lab-prepared students showed a statistically significant difference in favor of the lab students. It was recommended that a followup study be made on the subjects of this study and that a more controlled investigation be done on developmental math students in both formats in 1990-1991, to include analysis of math SAT scores and of learning disabled students in the populations and to include student reaction to delivery format.

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Chapter 1

INTRODUCTION

Brenau College is a small, private, four year liberal arts institution founded in 1878 and located in Gainesville, Georgia (Brenau College, 1988). The primary day time population of the college consists of traditionally aged (eighteen to twenty-two year old) residential students largely from high schools in the State of Georgia (Hale, 1989). Admission to Brenau requires a combined Scholastic Aptitude Test score of 800 although the Admissions Committee may admit students showing promise for success who do not meet this criterion (Brenau College, 1989). In fact, many students with weak mathematics backgrounds are admitted to the College each year and developmental math coursework is required of many before entering the college's required College Algebra course (Loebl-Crowder,1988).

All freshmen and transfer students entering Brenau are administered the Brenau Math Placement Test which consists of a computation section (Part I) and an elementary algebra section (Part II). Based on this test, students scoring below seventy percent on the first part are assigned to take DS 102, Fundamentals of Math I (basically arithmetic review). Those scoring seventy percent or above on Part I but below seventy percent on Part II are assigned to DS 104, Fundamentals of Math II (elementary algebra).

Those scoring at seventy or above on Parts I and II are assigned to MS/CS 110, College Algebra, the required core math course for all Brenau students.

Until the fall of 1989, all developmental math courses at Brenau were taught by the traditional teacher-paced lecture method, although using a programmed type textbook. Typically a DS 102 (arithmetic) class could contain fifteen to twenty students and a DS 104 (elementary algebra) lecture class, twenty-five to thirty students. A proposal was made to the administration in 1987 and again in 1988 that a structured math lab with sections limited to fifteen students be designed to replace the lecture format in developmental math "to facilitate individualized instruction and individualized learning" (Loebl-Crowder, 1988). The rationale for the proposal was based on the vast differences in the backgrounds of students entering college today and the inadequacy of instruction which presumes all students have the same mathematical voids. It was proposed (Loebl-Crowder, 1988) that individualized instruction via a self-paced math lab approach would:

(1) meet the individual needs of each student and allow students to concentrate on their areas of weakness and not waste time on what they already know.

(2) promote success and self-confidence in a discipline that historically intimidates and defeats many students (especially women).

(3) assure one-to-one interaction with the instructor.

(4) encourage students to be self-directed and motivated by self-pacing of their own learning (with the instructor's guidance).

(5) eliminate the possibility of being exposed to new content before the necessary prerequisites have been learned.

Expectations were that this self-paced math lab approach would generally increase student success in math, speed up the process for many while allowing adequate time for those who need more, and ultimately enhance learning and even general retention at the college.

In the fall of 1989 a modification of the individually self-paced math lab proposal was initiated at Brenau College. Due to the unanticipated high numbers of students needing arithmetic remediation that quarter, combined with staffing considerations, the College organized four math lab sections for students placing into DS 102 (arithmetic) and two additional larger lecture sections of DS 104 (elementary algebra) for students placing at that level. The math lab continued into winter quarter allowing the DS 102 placements to complete DS 104 in the same laboratory format or exercise the option of a third quarter of laboratory remediation in the spring if necessary, as long as attendance and reasonable progress toward the course objectives were maintained.

Since scheduling for the fall quarter of 1990 is already underway, the issue of continuing the math lab as opposed to scheduling larger lecture sections of

developmental math has been raised by the administration. This study was an initial effort to analyze the relative effectiveness to date of the self-paced math lab approach to developmental pre-college algebra at Brenau.

This study compared the DS 104 final exam grades of students who studied in the DS 104 lecture format fall 1989 with students who placed into math lab (DS 102) and completed DS 104 as well in that same quarter in the self-paced lab format. Second, a comparison of the winter 1990 algebra grades of students completing both DS 102 and 104 in the lab format in fall quarter were compared to the winter 1990 algebra grades of students who placed into and completed DS 104 in the lecture format in the fall. Finally, the DS 104 final exam grades of the lecture format students who took DS 102 (fall) and DS 104 (winter) in 1988-1989 were compared to the exam grades of the DS 102-104 math lab students in the fall and winter of the 1989-1990 academic year.

The research questions addressed in this practicum were as follows:

1. Is there a statistically significant difference in the means of the DS 104 final exam grades of students placed in and completing DS 104 under the lecture format fall 1989 as compared to those students placed in DS 102 and completing DS 102 and 104 under the self-paced laboratory format, fall 1989?

2. Is there a statistically significant difference in the mean algebra course grades for students coming into algebra winter 1990 from the DS104 fall 1989 lecture course and those coming into algebra from the DS102/104 fall 1989 laboratory format?

3. Is there a statistically significant difference in the mean DS 104 final exam grades after two quarters for the completing students who placed into the DS 102 fall 1988 lecture format and those placed into the DS102 fall 1989 lab format?

Chapter 2

BACKGROUND AND SIGNIFICANCE

The significance of this investgation to Brenau College lies in the potential for designing the most appropriate support that the results might suggest for the identified population of weak mathematics students entering the institution. Developmental math coursework prior to matriculation in the required core College Algebra course has been increasingly necessary for many Brenau freshmen and represents for many a significant roadblock to their academic progress in college (Loebl-Crowder, 1988). Consequently a math lab approach designed to enhance student self-confidence and success in developmental math by facilitating individualized instruction and learning was proposed and implemented with some of the developmental math students at the College in 1989. An evaluation of the results of the math lab delivery approach as well as its basis in research was needed to allow for appropriate scheduling decisions for developmental math courses in the fall of 1990. This investigation was specifically designed to review related literature and evaluate the 1989-1990 academic year experience with the math lab delivery approach to developmental math at Brenau College.

This study is relevant to the Learning Theory and Applications seminar since the rationale for a math lab

takes into consideration many well established principles of learning theory. The lab approach was designed to accommodate individual differences in rates and styles of learning and to promote the value of positive reinforcement, continual feedback, and active learner participation. As John Losak (1989) stated, learning theories often provide us, or bring to our conscious awareness, a rationale for what we have been doing all along; upon examination of what we're doing, however, we may decide that the application of learning theory could enhance learning.

Losak (1984: 39) points out that "in theory, instruction should be derived from learning principles." Fincher's (1985: 66) research on learning theory indicates that course organization, instructional methods, teacher expectations, and the means by which student performance is evaluated can be at times a major determinant of learning. Other variables affecting learning in college, according to Fincher, include class size, forms of reinforcement and feedback or knowledge of results.

Gagne (1970) defines instruction as the deliberate arrangement of the required conditions of learning, and he emphasizes the advantages of breaking down learning tasks into their less complex components. Planning for learning, in Gagne's (1970: 27) view, "is a matter of specifying and ordering the prerequisite capabilities within a topic to be learned..." A variety of instructional modes are both feasible and potentially effective and traditional modes are

not necessarily the best or the worst. What is important, suggests Gagne, is thoughtful design and management of the learning environment to match the population and purpose of instruction (Gagne, 1970: 379).

Programmed learning and the more modern version of Computer Assisted Instruction (CAI) have been one type of response to the need for adaptive variety in instructional modes. The Keller method of Personalized Systems of Instruction (PSI) in particular was designed to address the issue of individual pace and to do away with lecturing and rigid group scheduling (Bower and Hilgard, 1981: 573). There have been several approaches to individual differences in learning (Bower and Hilgard, 1981: 560). Bloom and his associates adopted J. B. Carroll's 1963 model of aptitude for a task as being essentially the time required for the individual to master the task. The instructional plan called "mastery learning" was the result. Horton (1981) defines mastery learning as "the attainment of adequate levels of performance on tests that measure specific learning tasks." The assumption is that nearly everyone can learn everything in the curriculum at a given level of competence if the learner's previous knowledge and attitudes toward the subject are accounted for, if instruction is of good quality and perhaps most importantly "if adequate time on the task is allowed to permit mastery" (Horton, 1981).

In their 1983 review of individualized systems of instruction in secondary schools, however, Bangert, Kulik

and Kulik concluded that individualized teaching systems have only a small effect on student achievement and did not contribute significantly to student self-esteem, critical thinking ability or attitudes toward subject matter. The authors did, nevertheless, find that studies in the college setting produced strikingly different results, perhaps attributable to age and greater level of maturity of the learner. Bagert, Kulik and Kulik (1983: 152) suggest college students may be better prepared to work under conditions of independence and freedom whereas elementary and secondary school students may need more stimulation, guidance, support and constraint. Cameron Fincher (1985) suggests that the self-management required of individualized learning methodologies may not have been mastered by many learners even at the college level, concluding that "alternative learning is <u>not</u> an alternative for all students."

Chapter 3

PROCEDURES

The ex post facto raw data for this study were obtained from the Brenau registrar's office and from the records of the Department of Math and Science. One t-test and two z-tests were performed as described below and outlined in Table 1. A sample size of between ten and thirty students was anticipated in each group, although in fact one sample contained only eight and another contained thirty-four. Since the degrees of freedom established in two of the three comparisons of means were greater than thirty, a z-test was used in those cases rather than the t-test originally proposed.

A first analysis explored whether there was any statistical difference in the DS 104 developmental algebra final exam grade means between students in DS 104 lecture format, fall 1989, and those completing DS 102 (developmental arithmetic) as well as DS 104 in the math lab in fall of 1989. A z-test for independent groups at the .05 level of significance was used.

In a second analysis, the winter quarter 1990 algebra grades of students placing into the developmental algebra (DS 104) lecture course in fall 1989 were compared to the winter quarter 1990 algebra grades of those students who placed into developmental arithmetic in the self-paced math lab fall of 1989 and who completed the outcomes of

both DS 102 and DS 104 in that single quarter. The means of the algebra course grades were computed for each group and a two tailed z-test was performed at the .05 level of significance.

Table 1

The Independent and Dependent Variables for the Three T/Z-Tests Performed in this Study

T-Test	Independent Variables	Dependent Variables
Test One	Fall 1989 DS 104 Lecture Class	Mean of DS 104 Final exam grades
	Fall 1989 DS 102-104 LAB (complete in one quarter)	Mean of DS 104 Final exam grades
Test Two	Fall 1989 DS 104 Lecture Class	Mean of CS 110 grades for DS 104 Lecture grads.
	Winter 1990 CS 110 College Algebra	
	Fall 1989 DS 102-104 LAB (complete in one quarter)	Mean of CS 110 grades for DS 104 LAB grads.
Test Three	Fall 1988 Winter 1989 DS 102 DS 104 Lecture Lecture Class Class	Mean of DS 104 Final exam grades
	Fall 1989 Winter 1990 DS 102. . .104 MATH LAB	Mean of DS 104 Final exam grades

Finally, lists of students enrolled in the DS 102 and DS 104 lecture courses in the fall and winter of 1988-1989 along with their final exam grades were compiled. Students and grades from the math lab DS 102-104 self-paced course taught fall and winter of 1989-1990 were also compiled. Each DS 102 and each DS 104 course was taught using the same programmed textbook and comprehensive final exams were the same in the comparable courses, regardless of delivery format. The means of the final exam grades in DS 104 were computed for each format and a two-tailed t-test for independent groups performed at the .05 level of significance to determine any significant mean difference.

Though not originally part of the proposed procedural design for this practicum, the math SAT (Scholastic Aptitude Test) scores for each of the groups under study were compiled as well since they were readily available and could potentially provide interesting comparative data. The means of the SAT scores were computed for each of the six groups examined. No math SAT score was available for each of five international students and two returning adult women in the overall study. For this study, no statistical analyses were undertaken to compare the significance of difference in the mean SAT scores; the data were compiled to see if any general trend might be observed that would suggest further statistical study.

One major assumption of this study was that, given the comparable placement test score cutoff points, the

populations placed in comparable courses (DS 102 or DS 104) during different time periods or academic years were still representative of the same population. The limitations of this study included the lack of randomly chosen experimental and control subjects in each delivery format and the lack of control in the assignment of teachers to each format. In addition, some classes were taught in 50 minute daily sessions (lab) whereas others met twice a week for two hour sessions (DS 104 lecture, one section) which could influence the conditions of learning. Finally, each student's personal level of motivation, personal study habits and strategies, and individual situation represented uncontrolled variables. The math lab format, furthermore, allowed students the option of completing DS 102/104 in one, two or even three quarters without receiving a failing grade if attending class regularly and making reasonable progress toward course goals. DS 104 placements in the lecture format, on the other hand, had only one chance to complete. Despite these limitations, however, it was believed that an analysis of the existing data would be beneficial to the institution.

Chapter 4

RESULTS

The final exam grades for all DS 104 completers in this study as well as the algebra course grades for CS 110, winter 1990, were compiled for the corresponding groups under study. In a first analysis, the final exam scores of the thirty-four students who started and completed the DS104 (developmental algebra level) lecture format fall quarter 1989 yielded a mean score of 87.26 with a standard deviation of 8.78. This was compared to a mean final exam score of 86.12 with a standard deviation of 6.60 for those seventeen students who placed into DS 102 (developmental arithmetic level) laboratory format and who completed both the DS 102 and DS 104 requirements in one quarter of lab, fall 1989. The seventeen lab completers came from an original enrollment of fifty-nine in the DS 102-104 self-paced lab format which allows students at least two quarters to complete both levels of developmental math, assuming reasonable progress and adherence to the attendance policy.

A z-test to compare the DS 104 final exam grade means at the .05 level of significance was performed resulting in a computed z-value of 0.4750. The null hypothesis of no significant difference between the means of the two groups was accepted since the critical z-value was 1.96. Table 2 summarizes the data as well as comparing the

mean math SAT (Scholastic Aptitude Test) scores of the two populations.

Table 2

Enrollments, Sample Size, Mean SAT-M Scores, and Means/ Standard Deviations of DS 104 Exam Grades for Fall 1989 Completers in Lecture and Lab Formats TEST I

Fall 1989	Enrolled #	"N" Com-pleters	Mean SAT-M Completers	Mean DS104 Final Exam	Standard Deviation
DS 104 Lect.	34	34	421	87.26	8.78
DS 102-104 Lab	59	17	347	86.12	6.60

A second analysis explored the difference in mean algebra course final grades for winter 1990 between thirty students who took developmental algebra (DS 104) in the lecture format fall 1989 and sixteen students who placed into DS 102 (developmental arithmetic) and completed both developmental arithmetic and developmental algebra in the laboratory format in a single quarter, fall 1989. The mean algebra course grade for the DS104 lecture format graduates was 76.3 with a standard deviation of 13.04 as compared to 77.56 with a standard deviation of 7.26 for the students graduating from the laboratory format in one quarter.

A z-test at the .05 level of significance was performed to compare the means, with a critical z-value of 1.96 established. The computed z-value was -0.3576 and thus the null hypothesis suggesting no significant difference between the means of the two populations was accepted. Table 3 summarizes the data used for this analysis including the average math SAT scores for each of the populations studied.

Table 3

Comparison of the Winter 1990 CS110 Final Course Grade and Math-SAT Means of Graduates of DS 104 Lecture and Graduates of DS 102/104 Lab from Fall 1989 TEST II

DS 104 Format Fall 89	"N" Algebra Enrollees	Mean Math SAT Score	Mean CS110 Algebra Grades	Standard Deviation
DS 104 Lecture	30	406	76.30	13.04
DS102/104 Lab	16	401	77.56	7.26

The third analysis compared the means of the developmental algebra final exam grades of students in the traditional lecture format in the 1988-1989 academic year with students who completed the same material under the self-paced laboratory format during 1989-1990. The mean exam score for the lecture format was 59.5 with a standard deviation of 12.35. The mean final exam score for the

laboratory completers was 82.46 with a standard deviation of 6.33. A two-tailed t-test for independent groups at the .05 level of significance was performed. The critical t-value was established at 2.093 and the computed t-value was 4.1, resulting in a rejection of the null hypothesis and an assertion of the alternate hypothesis that a significant difference exists between the means of the two groups examined. Table 4 summarizes the data for this analysis as well as including the average math SAT scores for the two groups.

Table 4

Comparison of the DS104 Final Exam and Math SAT Means Between 1988/89 Lecture Format and 1989/90 Lab Format Students Completing in Two Quarters
TEST III

Format/Dates	"N" Com-pleters Winter	Mean Math SAT Scores	Mean DS104 Final Exam Grade	Standard Deviation
Lecture Fall 88 Wtr 89	8	344	59.50	12.35
Lab Fall 89 Wtr 90	13	357	82.46	6.33

It must be noted in the analysis of results for Test III that under the lecture format, fall 1988, seventeen students started out in developmental arithmetic (DS 102) of

which group ten enrolled in the continuation course, developmental algebra DS 104 in the winter of 1989. The seven "non-continuers" included failures, withdrawals, incompletes and self-chosen non continuers. Of the ten winter enrollees, eight completed (i.e. received a final grade) though not necessarily with a passing or acceptable grade; the remaining two were an incomplete and a withdraw.

Of the fifty-nine DS 102 laboratory starters in fall 1989, seventeen completed both developmental arithmetic and developmental algebra in one quarter, leaving a total of forty-two lab students still pending. Of these, twenty-six enrolled in lab in the winter continuation course; the other sixteen either withdrew during fall quarter, left school or failed to meet minimum progress or attendance standards for the lab thus receiving a fall grade of F. During the winter quarter lab, thirteen of the twenty-six enrollees satisfactorily completed the course requirements. Unlike the lecture format, those not meeting the minimum pass requirements but making reasonable progress had the option of an incomplete ("I") grade and the opportunity to take a third quarter to complete the required outcomes. Ten students were assigned this option but no final results were availabe on them. The remaining three students either withdrew from or failed the winter quarter of lab. Table 5 summarizes these enrollment figures.

Table 5

Enrollment and Attrition in Fall and Winter DS 102/104 Courses for Lecture 1988-1989 and Lab 1989-1990 Formats

Format and Dates	#Fall Starters DS 102	#Fall Com-pleters DS 104	# Non-Contin-uing after fall	#Fall Starters Enrolled DS 104 winter	Winter quarter com-pleters DS 104
Lecture Fall 88 Wtr 89	17	0	7	10	8
Lab Fall 89 Wtr 90	59	17	16	26	13

Table 6

Summary of Results of the Three Z/T-Tests Performed for This Study

Test	Degrees of Freedom	Critical Z/T	Computed Z/T	Reject/Accept Null Hypothesis
Test I	49	1.96	0.4750	Accept
Test II	44	1.96	-0.3576	Accept
Test III	19	2.093	4.0911	Reject

Table 6 summarizes the results of the three tests performed. The null hypothesis was accepted in Test I indicating no statistically significant difference in the mean developmental algebra final exam grades between students placing in DS 104 and taking the course in the lecture format when compared to a group of students placing in DS 102 and completing DS 102 and 104 requirements in one quarter. In Test II the null hypothesis was likewise accepted. This indicated that no statistically significant difference in the means of the winter '990 algebra course grades was discovered when comparing a group of algebra students who had placed into and completed developmental algebra in the lecture format fall 1989 with a group who had placed into developmental arithmetic and completed both developmental arithmetic and developmental algebra in the fall 1989 self-paced lab class. In Test III the null hypothesis was rejected. A statistically significant difference in the DS 104 final exam grade means was found to exist between the 1988-1989 group completing DS 102 and 104 in the lecture format in two quarters as compared to the 1989-1990 group completing the same material in the laboratory format. The laboratory format produced the significantly higher mean score.

Chapter 5

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

An analysis of the results of the three tests performed in this study strongly supports the potential value of the math lab approach to developmental arithmetic and developmental algebra. The acceptance of the null hypothesis in Test I of the study suggests that motivated students who complete DS 102 and 104 in one quarter through the self-paced math lab fare just as well on the DS 104 final exam as those students placed directly into DS 104 to begin with and completing that DS 104 material in one quarter of a lecture class. The results imply that students who place into DS 104 initially might benefit from either delivery format, but those students placed in DS 102 have a distinct opportunity in the self-paced lab format to "save" a full quarter of developmental study time. Such achievement in and of itself might reasonably be expected to raise student self-esteem and enhance further learning.

The acceptance of the null hypothesis in Test II of the study likewise suggests that students successfully completing both their developmental arithmetic and developmental algebra in one quarter of a self-paced lab format achieve statistically as well as those students who required only developmental algebra and successfully completed it in one quarter of the DS 104 lecture format.

The results of both Tests I and II imply that a reasonable number of students who place into developmental arithmetic do not need two quarters to remediate weak mathematics backgrounds prior to successfully undertaking the required college level core algebra course.

The rejection of the null hypothesis in Test III of this study suggests further support for the math lab option in developmental mathematics. When the lecture method used for DS 102 placements in 1988-1989 was compared to the lab method used in 1989-1990 a statistically significant difference in the mean DS 104 final exam grades was found in favor of the lab format group. Of the seventeen students enrolled in the DS 102 lecture class, fall 1988, eight or forty-seven percent of the original enrollees completed the winter DS 104 lecture class. Of the eight completers, however, there were no "A" grades, one "B", two "Cs", three "Ds", and two failures. Since no grade below a "C" is considered acceptable for moving into College Algebra, only three of the eight completers, or eighteen percent of the original enrollees from fall 1988 successfully completed the developmental sequence. The average math SAT for the three successful completers was 357 as compared to 344 for the eight overall completers in the course. Of the seventeen original starters, all but three had SAT scores on file and the mean math SAT for those starters was 324.

In contrast, of the fifty-nine students enrolled in the DS 102 lab class, fall 1989, thirteen successfully completed (with a grade of "C" or better) after two

quarters. When added to the seventeen successful DS 102/104 completers in the single fall quarter of lab this represented completion within two quarters by a total of thirty or fifty-one percent of the original enrollees in math lab. The mean math SAT score of the thirty math lab completers was 357; the mean math SAT for fifty-four of the fifty-nine starters in the fall 1989 DS 102 lab (five students had no score on file) was 343, or nineteen points higher than the 1988-1989 lecture starters. Despite this observed difference in mean math SAT scores, when combined with the outcome of Tests I and II, the results of Test III also imply the possibility that the self-paced laboratory approach enhances student motivation and self-esteem, encouraging higher achievement and higher completion rates in developmental algebra.

Several recommendations for further research emerge from the results of this study. First, it is recommended that a controlled study be organized for 1990-1991 in which randomly selected samples of students from among both DS102 and DS 104 placements are assigned to the math lab or lecture delivery formats. Class size and instructor should also be controlled for most meaningful results. This recommendation and the results of this study have been shared with the Chairman of the Math/Science Department who has the responsibility for scheduling developmental math courses and who is amenable to further research on the topic.

A second recommendation for further study of Brenau's developmental math delivery formats would entail a consideration of the placement and performance of learning disabled students accepted to Brenau's Learning Disabilities (L.D.) Program and enrolled in developmental math. Further analysis of the populations reviewed in this study broken down by identified learning disabled and non learning disabled, and taking into consideration their DS 104 final exam grades, algebra grades and math SAT scores, might reveal trends not recognizable when the L.D. and non L.D. groups are mixed. In addition, any further study of the math lab approach as recommended above should consider the distribution of L.D. students in the populations studied. This recommendation will be shared with both the Math/Science Department Chairman as well as the Director of the Learning Disabilities Program for cooperative implementation.

Thirdly, it is recommended that a followup study be undertaken to complete this initial research by tracking the DS 104 winter 1990 lab completers on into CS 110 College Algebra, analyzing their degree of successful completion as compared to DS 104 lecture format graduates. In addition, those lab starters who did not complete in two quarters in 1989-1990 should be tracked and their SAT scores, L.D. status, etc., be analyzed for significant trends. This further research could be undertaken by the Math/Science Department and/or the Director of Institutional Research in

conjunction with the controlled study recommended above and anticipated for 1990-1991. Data collected for the present study would provide the names, I.D. numbers, math SAT scores, and current status of subjects to be followed.

Finally, it is recommended that as many students as possible who were included in this study be surveyed for their reaction to and feedback on the lab delivery format or lecture format of developmental math, as appropriate. In addition, such a student reaction survey should be built into the 1990-1991 study recommended herein. This could be accomplished next year as part of the normal faculty/course evaluation procedure in the last week of each course. The current year's participants could be surveyed by mail.

Implementation of any or all of these recommendations has the potential to enhance understanding of Brenau's enrolled population with respect to mathematics preparation, learning style, and potential for achievement. Continued research on and analysis of the math lab delivery format could be expected to more clearly identify the specific populations most likely to benefit from the individualized, self-paced approach. This data would in turn allow for improvement and refinement of the placement process and the scheduling process to the ultimate benefit of the developmental math students matriculating at Brenau.

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